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INSTITUTE OF RADIOLOGICAL AND ENVIRONMENTAL PROTECTION
OPERATION UNIT OF GEOCHEMISTRY AND IMPACT OF TRANSURANICS

RADIOLOGICAL MONITORING IN THE REGION OF PALOMARES
(REPORT ACCORDING TO SECOND SEMESTER OF 1989)

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FEBRUARY 1990

RADIOLOGICAL MONITORING IN THE REGION OF PALOMARES
PERIOD: SECOND SEMESTER OF 1989

In accordance with the program established and entitled "Radiological monitoring in the Region of Palomares. Program for 1989", the activities related to the monitoring in this region, conducted during the second semester of 1989, were as follows:

1. Monitoring of Persons

1.1. Monitoring in 1989

According to the criteria given in the lists which were established in May, and which included altogether 181 persons, 151 have been checked, one more than foreseen, distributed as follows:

- Of Group I, section a) consisting of 31 persons who should all have been checked, if possible, in the first part of the campaign, during June and July, 12 were checked, and another 10 in October and November, so that altogether 22 persons were checked, and nine have not;

- Of Group I, section b) consisting of 25 persons living in Villaricos, 10 persons were checked during the first part of the campaign and two during the second;

- Of Group I, section c) consisting of 23 children who were to come for the first time, 15 of them during the first stage of the campaign and four in the second stage, were checked medically and analyzed by methods of measurement of biological elimination and direct measurement of anthropometry, that is, altogether 19.

¹Numbers in margin indicate foreign pagination.

- Of Group II, section a) consisting of 37 persons, 10 of them were checked in the first stage and 19 in the second stage, so that altogether 29 persons were checked over the year, while eight remain to be checked.

- Of Group II, section b) consisting of three persons of Villaricos, all were checked in the second stage of the campaign.

- Of Group II, section c) consisting of four children who had been previously checked, three of them were checked in the second stage.

- Of Group III, section a) a consisting of 58 persons of which it was requested that at maximum 30 should come, two were checked in the first stage and 22 in the second, giving a total of 24 persons.

Finally, 39 persons who accompanied the children and other residents of the region were checked.

1.2. Dosimetry of 1989

Of all the persons analyzed, in the first 72, the measurements were conducted by alpha spectrometry of Pu-239 + Pu-240 and Am-241. The rest of the analyses depended on the measurement phase.

The results obtained in these 72 persons were as follows:

- Six persons showed values of Pu-239 + Pu-240 higher than the minimum activity detectable by our method of analysis.

The concentration values have been as follows:
1.46, 1.5, 1.5, 4.4, 4.87 and 5.29 mBq in 24 hours
urine.

Of these six persons, two had given positive plutonium results in urine previously. The effect integrated equivalent dose in 50 years, which resulted from an acute inhalation at the time of the accident, was as calculated 26.5 mSv and 53 mSv. The present results (1.46 and 1.5 mBq/24 hrs) confirmed the contamination and the doses calculated.

The four remaining persons had given positive results for the first time, one of them being a child (4.87 mBq/d) and another a resident of Villaricos who was at Palomares at the time of the accident (1.5 mBq/d).

According to the established criterion, the doses are only calculated when there are two or more analyses with positive results, because these persons will be submitted to another check next year.

- Three persons gave results of Am/241 higher than the minimum activity detectable by our method of analysis. The values obtained are: 13.2, 2.18, and 2.24 mBq.

The value 13.2 mBq corresponds to a female person, 73 years old, now residing in Palomares, because she was there at the time of the accident, and had positive results in 1967.

These three persons had previously shown positive Pu-239 + Pu-240 results. The effective equivalent doses

integrated in 50 years, which were calculated as a consequence of an acute inhalation of plutonium at the time of the accident, are 100.3, 139 and 89.71 mSv respectively.

We are beginning to see Am-241 in persons who had Pu-239. The possibility is suggested that this Am-241 comes from the decay of the Pu-241 which was incorporated at the time of the accident.

Obviously, the mechanism of actuation of the radiological monitoring provides the subsequent or successive monitoring of the persons who had given positive results for plutonium or americium for the first time.

The percentage of persons with positive results, six out of 72 for Pu (8.3%) and 3 out of 72 for Am (4.2%) confirms the order of occurrences higher than the LID calculated for the period 1967-1985 (Ref. 3) of 7.7% (86 cases out of 1155). The distribution by categories in this period corresponds to a normal logarithmic function, and also, obviously the dose distribution.

The most adequate parameter for evaluating the impact to which the population of Palomares was subjected is the collective dose ("de facto" situation and subgroups which cannot be correlated with the actual risk). Nevertheless, the obtainable parameters are the median and the average.

The median which is represented by the most frequent value of the effective equivalent dose integrated in 50 years for the average person of the critical group is less than 5 mSv. Therefore the results specified in this report,

besides being foreseeable, do not modify conclusions previously obtained or reflected.

1.2.1. Medical Monitoring

In the second stage of the Program of Radiological Surveillance in the region of Palomares for 1989 (see Doc. MSA01/PI002/89) implemented in the period between 3-7-89 and 11-12-89, 109 persons were checked medically, divided in the following manner;

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Group 1-A	11	persons	
Group 1-B	12	"	
Group 1-C	9	"	
Group 2-A	20	"	
Group 2-B	3	"	
Group 2-C	3	"	
Group 3-A	22	"	
Not included in the list	29	"	(accompanying)

In the medical examinations conducted, according to the directives provided by the Safety Guide No. 7.4 "Bases of Medical Monitoring of Workers Exposed to Ionizing Radiations" and the recommendations of International Agencies, no pathology could be detected at all which could be attributed to the incorporation of transuranic elements, coming from the residual contamination of the region.

We give below all the significant findings:

Absence of alterations	39
Slight alterations	38
Presence of pathologies	32

1. TUMORS (140-239)*	
Uterine myoma	2
Melanocytoblastoma "in situ"	1
2. DISEASES OF THE ENDOCRINE GLANDS, NUTRITION, METABOLISM AND IMMUNITY DISORDERS (240-279)	
Obesity	5
Hyperglycemia	4
Hypercholesterolemia	9
Hyperuricemia	2
Diabetes mellitus type II	5
Gynecomasty	1
Diffuse normally functioning goiter	1
*Code ICD-9 ^a revision	
3. DISEASES OF THE BLOOD AND HEMATOPOIETIC ORGANS (280-289)	
Ferropenic anemia	1
Macrocytic anemia	1
Leucocytosis	1
4. MENTAL DISORDERS (290-319)	
Depressive syndrome	5
Anxiety neurosis	5
Insomnia	1
5. DISEASES OF THE NERVOUS SYSTEM AND OF THE SENSORY ORGANS (320-389)	
Epilepsy	2
Migraine	3
Vasomotor cephalaea	2
Presbyopia	18
Hypermetropia	3
Myopia	11

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Astigmatism	3
Unilateral amblyopia	2
Decrease of the acuity of vision	1
Cataract	1
Eyeball enucleation	2
Pterygium	1
Decrease of the acuity of hearing	31
Bilateral impacted cerumen	2
Tympanoplasty	2
Meniere vertige	1
Nasal obstruction because of hypertrophy of cartilages	1
6. DISEASES OF THE CIRCULATORY SYSTEM (390-459)	
Varices of the lower extremities	1
First degree A-V blocking	1
Arterial hypertension	2
Hypertensive encephalopathy	1
Orthostatic hypotension	2
Transient cerebral ischemia	1
Peripheral arteriosclerosis	1
Ischemic cardiopathy	1
7. DISEASES OF THE RESPIRATORY SYSTEM (460-519)	
Polynosis	3
EPOC	2
Chronic asthmatic bronchitis	2
Acute bronchitis	1
Intrinsic asthma	2
Acute rhinopharyngitis	1
Acute pharyngitis	1
Chronic pharyngitis	1

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Tonsil hypertrophy	3	
Vocal chord polyp	2	
8. DISEASES OF THE DIGESTIVE TRACT (520-579)		
Duodenal ulcer	3	
Gastric ulcer	2	
Inguinal hernia	1	
Biliary lithiasis	1	
9. DISEASES OF THE GENITOURINARY SYSTEM (580-629)		
Renal lithiasis	2	
Urinary infection	3	
Renal polycystosis	1	
Hematuria and microscopic pyuria	11	
Prostatic syndrome	1	
Polymenorrhea	1	
10. DISEASES OF THE SKIN AND THE SUBCUTANEOUS CELLULAR TISSUE (680-709)		
Contact eczema	3	
Dermatitis by wasting		1
Acne	2	
Vitiligo	3	
Axillary hydrosadenitis	1	
Congelation urticaria	1	
Actinic Hyperkeratosis	2	
11. DISEASES OF THE OSTEOMUSCULAR SYSTEM AND THE CONJUNCTIVE TISSUE (717-739)		
Hygroma of the wrist	1	
Scapulohumoral periarthrititis	1	
Cervical spondyloarthrosis	2	
Cervicobrachial syndrome	1	

Dorsal scoliosis	1
Syndrome of radicular compression C7-D1	1
Dorsalgias	1
Lumbago	4
Osteoporosis	1
Asymmetry of lower extremities	1
12. CONGENITAL ANOMALIES (740-759)	
Cryptorchidism	1
13. CERTAIN DISEASES ORIGINATING IN THE PERINATAL PERIOD (760-779)	
Cubital paralysis, sequela of fetal erythroblastosis	1
14. POORLY DEFINED SIGNS, SYMPTOMS AND MORBID CONDITIONS (780-799)	
Rx. - Ventricular hypertrophy	5
Rx. Hypertrophy of the right cavities	2
Rx. Dilation of the aortic arch	1
Rx. Nodular hiliary and para- hiliary calcifications	5
Rx. Pulmonary emphysema	2
Rx. Reinforcement of the bronchovascular tissue	2
ECG AI hypertrophy	2
ECG VI hypertrophy	2
ECG Sinusoidal bradycardia	1
ECG Sinusoidal tachycardia	1
ECG Auricular fibrillation	1
ECG Extrasystole in bursts	1
ECG Incomplete bifascicular blocking	1

Reduction of the vital capacity in functional respiratory tests	2
Spirometry--Obstructive pattern	1
Albuminuria	3
Acetonuria	1
Hypocalcemia	1
Hypopotasemia	1
Gastric dyspepsia	1

15. TRAUMATISMS AND POISONINGS (800-999)

Instability of the knee, accident sequela	1
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The findings collected correspond to the pathology encountered every day in the periodic preventive examinations of workers, whether exposed or not to ionizing radiation, and in our opinion, there is no finding which would allow the suspicion of a morbidity specifically induced by radioactive agents.

2. Monitoring of the Environment

2.1. Soils

In connection with the tracking of the residual contamination of the soil, the activities conducted this semester are as follows:

2.1.1. Sampling

The following samples were taken:

- 55 superficial samples, corresponding to 11 points outside the zero contamination line, which gave values higher than the detection limit in the analyses conducted in

the first semester of this year 1989.

At each point a central sample and four samples at a distance of 150 meters in the direction of each of the four cardinal points, N, S, E, and W were taken.

- 45 samples obtained by soundings up to 1.5 m depth in the plots 2-0, 2.1 and 3-1.

2.1.2. Studies of Migration in Cultivated Soils

Radiochemical analyses were conducted of Pu in 24 samples, taken by soundings up to a depth of 1.50 meters in cultivated soils, to determine the migration of Pu and the effect on the types of cultivation.

On the basis of the values obtained which correspond to the implementation of 30 analyses, it is deduced that:

- the distribution of the plutonium concentrations tends to be more homogeneous in these soils than in uncultivated ones;

- the Pu concentration levels tend to decrease with the depth; but a greater depth higher values are observed than in uncultivated zones;

- a level of accumulation is observed in the ground between 70 and 90 cm depth with values of 23 Bq/gr and 35.8 Bq/gr in zones 2-0 and 2-2 respectively;

These levels might be determined by the existence in plot 2-0 of a minimum of permeability and porosity of the

soil at this depth and in plot 2-2 by an increase in the organic material content which might act as a reducing barrier.

- The 2-0 plot contains 97.63% of the total Pu in the superficial layer of the soil, 0-5 cm deep, while plot 2-2 has 51.2% of the total Pu homogeneously distributed in the layer 0-20 cm deep. This difference in distribution may be attributed to a difference in the cultivation frequency.

2.2. Air

The activities implemented during this period have been as follows:

2.2.1. Sampling

In the station corresponding to reference 2-1 and 2-2, the continuous weekly sampling is conducted by the method foreseen.

In station P (Urban Zone) continuous weekly samples were taken until the second fortnight of December, at which time it was decided to break off the sampling for a short time in view of the objection raised in October by a neighbor of Palomares before the Town Hall of Cuevas del Almanzora.

This objective referred to an acute, continuous and very disturbing noise produced by the equipment.

That is why the mayor recommended that the problem be solved within the shortest possible time.

It was decided to install the sampling device near its present location, at a distance of around 10 meters, a position which would allow the attenuation of the sound while maintaining the original sampling conditions. The incorporation of a noise abatement system is also being studied.

2.2.2. Plutonium Concentration

The radiochemical analyses to determine the concentration of Pu-239 + Pu-240 in the air, were conducted in the following weekly samplings:

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- Station 2-1	26 samples	1988
- Station 2-2	26 samples	1988
- Station P	47 samples	1984

The samples of the Station P corresponding to 1984 were processed separately and by electrodeposit monthly to reduce the counting time by alpha spectrometry.

The 1988 samples correspond to those taken weekly in Stations 2-1 and 2-2 during the time from January 2 to July 2. The values obtained in the P Station in that same period were given in the report of the first semester of that year of 1989.

We wished to make an analysis in the P Station, in view of the fact that this is the station most representative of risk of the public.

The values of the concentrations of Pu-239 + Pu-240 for 1984 are indicated in Table 1. This table includes the

results already presented in the report corresponding to the second semester of 1986 to give an idea of the whole.

The following is deduced from these values:

- The average value of Pu concentration in the urban area of Palomares (Station P) in 1984 was:

P Station: $4.9 \mu\text{Bq/m}^3$

- The concentration category in 1984 was:

. $0.2 - 14.8 \mu\text{Bq/m}^3$

Both the average and the maximum value of the Pu concentrations in the P Station in 1984 were much lower than the concentration derived in the air (5900 Bq/m^3) for plutonium compounds of class Y, according to what is derived from the value established by Spanish legislation.

The values of the concentrations of Pu-239 + Pu-240 in the first semester of 1988 in station 2-1 are given in Table 2.

In view of the results, it seems it may be deduced that the building of a pond to store the water near this station during the period from February 20 to May 7, caused a clear increase of the concentrations in this station, caused by the subsequent movement of the soils, with a maximum value of $1575 + 165 \mu\text{Bq/m}^3$, coinciding with the week when the building of the pond was complete.

According to these values, it was found that:

- The average value of plutonium concentration in the 2-1 station during the first semester of 1988 was:

Station 2-1: $99.2 \mu\text{Bq/m}^3$

The weekly concentrations at this station, 2-1 during the first semester of 1989, were within the range:

. 1.6 - 1575 $\mu\text{Bq}/\text{m}^3$

- Both the average and the maximum concentration of plutonium during the first semester of 1988 remained below the concentration derived in the air (5900 $\mu\text{Bq}/\text{m}^3$) for the plutonium compounds of class Y, according to what may be derived from the value fixed in the Spanish legislation (2) for the limit of annual incorporation by inhalation.

The values of the concentrations of Pu-239 + Pu-240 in the 2-2 station are given in Table 2.

From the values indicated it is deduced that:

- The average value of plutonium concentration in this 2-2 zone during the first semester of 1988 was:

Station 2-2: 8.4 $\mu\text{Bq}/\text{m}^3$

- The weekly concentrations of plutonium in that 2-2 region during the first semester of 1988, were within the range:

. 0.2 - 22.8 $\mu\text{Bq}/\text{m}^3$

Both the average value and the maximum concentration of plutonium during the first semester of 1988 were much lower than the concentration derived in the air (5900 $\mu\text{Bq}/\text{m}^3$) for plutonium compounds of class Y, according to what may be derived from the limiting annual value of incorporation by inhalation, established in the Spanish legislation.

2.2.3. Concentrations of Americium

The radiochemical analyses to determine the Am-241 concentration in the air were conducted on 26 samples of station 2-1 and 26 samples of station 2-2, corresponding to the first semester of 1988.

The chemical treatments of the radioanalytical process were applied independently to each weekly sample, but the electrical deposits and subsequent measurement by alpha-spectrometry were conducted in composite samples corresponding to 4 or 5 weeks.

The results of 58 samples analyzed during this second semester are given in Table 3.

It is deduced from these calculations that:

- In station 2-1, the values of concentration of Am-241 in the air of the region were lower at any moment than the detection limit of our method of analysis, $0.2 \mu\text{Bq/m}^3$.

- In station 2-2, the average value of the concentration of Am-241 in the air of this zone during the first semester of 1988 was:

- . $0.73 \mu\text{Bq/m}^3$

- The range of Am-241 concentrations in this station 2-2, during the first semester of 1988, was:

- . $0.15 - 1.0 \mu\text{Bq/m}^3$

- Both the average and maximum value of the concentration in the air during this semester remained far below the limit of concentration derived in the air for all the Am-241 compounds, which is $2,360 \mu\text{Bq/m}^3$ according to Spanish legislation (3).

2.3. Vegetation

2.3.1. Sampling

During the period corresponding to the second half of 1989, the following products of cultivation were collected:

- Two samples of melons with their respective plants, coming from zone 2. One of the samples corresponds to plot 2-0, and the other to plot 2-1. They were collected at the beginning of September, coinciding with the cultivation period.

2.3.1. Plutonium Concentration

During this second semester, 30 analyses were conducted corresponding to 21 samples of barley, 8 of wheat, and one watermelon plant collected in 1988, and 20 analyses of tomatoes relating to samples taken in the first semester of 1989.

The values corresponding to the results obtained in the samples of 1988 are given in Tables 4, 5 and 6.

From these values, it seems possible to deduce that, in general, the samples of cereal analyzed show contamination by Pu-239 + Pu-240, and that their values are very closely related to the value of residual contamination of the place of cultivation, the level of wheat and barley being less in the grain than in the straw and spicule.

The value corresponding to the fruit of the watermelon plant (Table 4) was given in the report of the first

semester of 1989, but is included again in this table to obtain a complete survey.

The average values corresponding to the samples which gave concentrations higher than the minimum detectable by our method (LID = 0.002 Bq/kg) are as follows:

Barley

Zone 2:

Grain	=	7.5 Bq/kg
Spicule	=	221 "
Straw	=	1504 "

Zone 3:

Grain	=	1.2 Bq/kg
Spicule	=	12.2 "
Straw	=	17.2 "

Zone 5:

Grain	=	0.002 Bq/kg
Spicule	=	5.4 "
Straw	=	0.002 G

Wheat

Zone 2-0:

Grain	=	20 Bq/kg
Straw	=	162 "

Zone 3:

Grain	=	0.002 Bq/kg
Spicule	=	8.2 "
Straw	=	0.53 "

Zone 5:

Grain	=	0.002 Bq/kg
Spicule	=	6.9 "
Straw	=	0.002 "

Watermelon

Zone 2:

Plant	=	0.72 Bq/kg
Fruit (epicarp)	=	0.05 "
Fruit (rest)	=	0.002 "

From these views it is deduced that:

- In view of the risk implied by the contamination of the barley, account must be taken that both the consumption of grain and the straw for the animal fodder decreases greatly the risk derived from man's ingestion of meat, because of the factors of gastrointestinal absorption, 10^{-4} - 10^{-5} , and the factor of transfer to the meat. Consequently, the resulting risk will be very small.

- With regard to wheat, only that coming from zone 2-0 has a contamination worth being considered. This value corresponds to a single sample, collected in a small plot of the zone 2-0, where maximum contamination occurs, and where there has been only sporadic cultivation. The plutonium concentration measured is less than that tolerated by the EEC for direct food products for man in cases of accident, and their consumption would give rise to a practically negligible risk. This value 20 Bq/kg represents according to our legislation, the 10,000th of the annual limit for ingestion for plutonium compounds of Y class.

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- The watermelon plant corresponding to zone 2, has a slight contamination which is related to the contamination observed in the sample of the epicarp of the fruit before washing and which reveals once again the importance to be assigned in this zone to the phenomenon of resuspension.

- The results corresponding to the samples of tomato collected in the first semester of 1989 are indicated in Table 7, 8, 9 and 10.

From these values, it is deduced that the values of concentrations of Pu-239 + Pu-240 are lower than the detection limit of our analytical method in all the washed tomato samples analyzed. The samples of unwashed tomatoes have a slight contamination in the range of 0.002-2.24, which indicates that there is an external contamination of the sample, and confirms again the effect of the phenomenon of resuspension in the contamination of the crops.

2.3.2. Concentration of Am-241 in Vegetation

During this second semester of 1989, it was not possible to conduct any measurement of Am-241 because of technical problems in our low energy gamma spectrometry equipment. These problems were solved within a short time, since new equipment is being installed which will permit us to continue with these analyses.

2.4. Animals

2.4.1. Sampling

During 1989, eight samples of milk were collected from the goat, which we were monitoring and which pastured during the whole year in the whole Palomares region.

These milk samples are weekly composite samples and cover the period of June and July, 1989.

2.4.2. Contamination by Plutonium

During this semester, the eight weekly samples of goat milk taken in Palomares were analyzed radiochemically.

Of these eight analyses, five were measured by alpha-spectrometry to determine the concentration of Pu-239 + Pu-240 and three are in the phase of electrodeposit pending measurement.

The values obtained are given in Table 11.

From these values, it is deduced that:

- Two milk samples show a contamination higher than the detection limit.

These values are: 20.19 mBq/l and 41.83 mBq/l.

The ingestion of one liter of milk every day for a year with the highest value of 41.83 mBq/ for the critical group (one-year old children) would give rise to an effective equivalent dose integrated in 70 years of $55 \times 10^{-1} \text{mBq/l}$, which corresponds to 0.0079% of the dose limit recommended by ICRP for members of the public, 1 mSv/year.

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3. Supplementary Studies

In connection with the additional studies to the radiological monitoring in the Palomares region in 1989, the following activities were implemented:

3.1. Meteorology

During 1989, the meteorological station installed in Palomares was operating. Starting from September 16, because of a damage to the directional sensor, already remedied, there is no data on wind direction.

On Figures c.1 to c.9 the rising of the wind corresponding to each of the months of the registered period in 1989 are represented graphically.

From the analysis of the data, it is deduced that:

- There is a marked difference in the predominant directions, while it was observed that during the hours of maximum isolation, the general tendency is in the ENE-SSE direction, and at night, accompanied by the drop in temperature, WNW-N winds dominate.

This behavior may be generalized to all the months of the studied year, except for a few days, probably corresponding to the passage of fronts, which makes the process of heating the soil difficult, giving rise to daytime situations similar to the night-time ones, with wind directions from WNW-N.

- The meteorological process observed is perfectly defined, considering that the Palomares meteorological station is located in a coastal region. Because of the difference in the physical properties between sea and land, these forced changes of flow, "breezes" take place. The predominant directions of the ENE-SSE sectors corresponds to the sea-land breeze and the WNW-N to the direction land-sea.

- During the summer months wind speeds are observed during the day much higher than the night-time ones;

- During the winter months, one may observe in the wind rising, that typical night-time situations occur during the day; this is due to the fact that in winter there is a larger number of days when the breezes are absent.

3.2. Studies on the Geochemical Association of Pu

The Pu distribution was studied as a function of the size of soil particles and components, which combined with the studies of lixiviation in depth made it possible to obtain interesting data on the environmental behavior of plutonium.

These studies were presented at the Second International Congress on "Chemistry and Migration Behavior of Actinides and Fission Products in the Geosphere" which was held in Monterey (California) from last November 6th to the 10th.

3.3. Studies on the Phenomenon of Resuspension

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A project has been planned making it possible to study experimentally the phenomenon of resuspension on the basis of the Palomares scenario.

The purpose of this project is to determine the specific parameters of zones with Mediterranean climatology and low precipitations, to reduce the uncertainties in the calculation of resuspension applying generic parameters.

4. Participants

The following CIEMAT personnel members have been involved in the development of activities leading to the collection of data and conclusions of this report:

Senior technicians: Emilio Iranzo, Jose Gutierrez, Begona Acena, Angel Bellido, Santiago Castano, Mrs. Asuncion Espinosa, Emma Iranzo, Enrique Mingarro, and Pedro Rivas.
Technicians: Camila Blanco, Ludivina Borrego, Milagros Carmona, Mrs. Carmen Guzman, Francisco Moreno, Mariano Moya, and Carmen Barros, responsible for the transcription and drawing up of this manuscript.

5. References

1. Radiological Monitoring in the Palomares Region. Program for 1989. CIEMAT/PRYMA/GIT/. M5A01/PI002/89. February 1989.
2. Regulations on Health Protection against Ionizing Radiations. B.O.E. No. 13, 15 January 1988.
3. Summarized Report on the Radiological Monitoring Implemented in the Palomares Region (Almeria) JEN7PRYMA/M1/A--/7/1985, June 1985.

Table 1. Concentration of Activity of Pu-239 + Pu-240 in
the Samples of Air in Palomares

CONCENTRACION DE PLUTONIO-239-240 ⁽²⁾			
PERIODO ⁽¹⁾	CASETA 2-1 ⁽³⁾	CASETA 2-2	CASETA P (Zona Urbana) ⁽⁴⁾
31-12-83 al 07-01-84 ⁽⁵⁾			14.8 ± 1.6
07-01-84 al 28-01-84			11.7 ± 2.1
28-01-84 al 04-02-84			≤ 0.2
04-02-84 al 25-02-84			11.7 ± 2.1
03-03-84 al 31-03-84			1.5 ± 0.3
31-03-84 al 07-04-84			≤ 0.2
07-04-84 al 28-04-84			1.5 ± 0.3
28-04-84 al 05-05-84			≤ 0.2
05-05-84 al 02-06-84			≤ 0.2
02-06-84 al 09-06-84			2.9 ± 0.4
09-06-84 al 30-06-84			≤ 0.2
30-06-84 al 07-07-84			1.7 ± 0.2
07-07-84 al 04-08-84			13.7 ± 2.1
04-08-84 al 11-08-84			6.7 ± 0.4
11-08-84 al 01-09-84			13.7 ± 2.1
08-09-84 al 29-09-84			6.0 ± 0.9
29-09-84 al 06-10-84			7.4 ± 0.3
06-10-84 al 03-11-84			6.0 ± 0.9
03-11-84 al 10-11-84			4.1 ± 0.3
10-11-84 al 01-12-84			1.3 ± 0.2
01-12-84 al 08-12-84			≤ 0.2
08-12-84 al 29-12-84			1.3 ± 0.2

Key: 1) period; 2) concentration of plutonium-239-240;
3) station; 4) urban zone; 5) to.

Table 2. Concentration of Activity of Pu-239 + Pu-240
in Palomares Air Samples

CONCENTRACION DE Pu-239 + Pu-240, $\mu\text{Bq}/\text{m}^3$			
PERIODO ①	CASETA 2-1 ③	CASETA 2-2	CASETA P (Zona Urbana) ④
02-01 al 09-01-88 ⑤	2.6 \pm 0.6	7.0 \pm 1.1	
09-01 al 16-01-88	2.7 \pm 0.6	\leq 0.2	
16-01 al 23-01-88	2.0 \pm 0.4	\leq 0.2	
23-01 al 30-01-88	3.2 \pm 0.6	\leq 0.2	
30-01 al 06-02-88	13.4 \pm 1.6	7.8 \pm 1.1	
06-02 al 13-02-88	44.7 \pm 5.4	21.1 \pm 2.7	
13-02 al 20-02-88	9.4 \pm 1.1	6.8 \pm 0.8	
20-02 al 27-02-88	2.3 \pm 0.6	\leq 0.2	
27-02 al 05-03-88	17.1 \pm 2.6	10.4 \pm 1.2	
05-03 al 12-03-88	18.6 \pm 2.5	3.6 \pm 1.0	
12-03 al 19-03-88	14.9 \pm 2.1	8.6 \pm 1.4	
19-03 al 26-03-88	157 \pm 17	8.6 \pm 1.4	
26-03 al 02-04-88	221 \pm 24	8.6 \pm 1.4	
02-04 al 09-04-88	38.9 \pm 5.4	8.6 \pm 1.4	
09-04 al 16-04-88	6.1 \pm 1.3	3.5 \pm 0.6	
16-04 al 23-04-88	2.9 \pm 0.6	16.9 \pm 1.9	
23-04 al 30-04-88	8.9 \pm 1.1	13.8 \pm 1.5	
30-04 al 07-05-88	1575.0 \pm 165	11.9 \pm 1.5	
07-05 al 14-05-88	165 \pm 17	8.5 \pm 1.5	
14-05 al 21-05-88	232 \pm 24	3.6 \pm 0.5	
21-05 al 28-05-88	1.6 \pm 0.2	16.0 \pm 2.0	
28-05 al 04-06-88	4.8 \pm 0.8	5.1 \pm 0.7	
04-06 al 11-06-88	2.1 \pm 0.3	4.7 \pm 0.7	
11-06 al 18-06-88	4.5 \pm 0.7	8.0 \pm 1.1	
18-06 al 25-06-88	15.4 \pm 2.3	22.8 \pm 2.7	
25-06 al 02-07-88	12.8 \pm 2.1	11.9 \pm 1.4	

Key: 1) period; 2) concentration of; 3) station; 4) urban zone; 5) to.

Table 3. Concentration of Activity of Americium-241 in the /28
Palomares Air Samples.

PERIODO (2)	CONCENTRACION DE AMERICIO-241 (1)		$\mu\text{Bq/m}^3$
	CASETA 2-1 (3)	CASETA 2-2	
			CASETA P (Zona Urbana) (4)
(5) 02-01-88 al 30-01-88	≤ 0.2	0.15 ± 0.04	
30-01-88 al 27-02-88	≤ 0.2	0.79 ± 0.15	
27-02-88 al 12-03-88		0.82 ± 0.19	
12-03-88 al 09-04-88	≤ 0.2	1.00 ± 0.17	
02-04-88 al 30-04-88	≤ 0.2	0.96 ± 0.16	
30-04-88 al 04-06-88	≤ 0.2	0.62 ± 0.12	
04-06-88 al 02-07-88	≤ 0.2	0.78 ± 0.14	

Key: 1) concentration of americium-241; 2) period; 3) station; 4) urban zone; 5) to.

Table 4. Content of Plutonium-239 in the Vegetation of the Area 2 in 1988.

FECHA DE ① DE MUESTREO	FINCA ②	VEGETAL ③		CONC. ACTIVIDAD ④ Bq/kg
		Especie ⑤	Parte ⑥	
30-5-88	M.S.N. (2-2)	Sandía ⑦	Fruto ⑧ (epicarpio)	0.05
"	" "	"	Fruto ⑨ (resto)	≤ 0.002
30-5-88	M.S.N. (2-2)	"	Hojas ⑩	0.72 ± 0.20
16-5-88	H.M.N.A. (625) (875)	Cebada	Paja ⑪	1504 ± 225
"	H.M.N.A. (625) (875)	Cebada	Grano ⑫	7.5 ± 1.3
"	H.M.N.A. (625) (875)	Cebada	Espícula ⑬	221 ± 34
"	H.P.T. (300) (275)	Trigo ⑭	Paja	162 ± 24
"	H.P.T. (300) (275)	Trigo	Grano ⑫	20 ± 2.2

Key: 1) sampling date; 2) estate; 3) vegetable; 4) concentration of activity; 5) species; 6) part; 7) watermelon; 8) fruit (epicarp); 9) rest; 10) leaves; 11) straw; 12) grain; 13) spicule; 14) wheat.

Table 5. Content of Plutonium-239 in the Vegetation of Area 3 in 1988.

FECHA DE MUESTREO ①	FINCA ②	V E G E T A L ③		CONC. ACTIVIDAD Bq/kg ⑥
		Especie ④	Parte ⑤	
16-5-88	J.C.N. (cat.497)	Cebada ⑦	Paja ⑧	4.6 ± 0.8
"	D.S.M. (cat.548)	"	Grano ⑨	LID
"	"	"	Espícula ⑩	8.6 ± 1.5
"	"	"	Paja	3.5 ± 0.7
"	J.N.P. (cat.778)	"	Grano	0.11 ± 0.03
"	"	"	Espícula	5.3 ± 0.9
"	"	"	Paja	LID
"	J.C.G (cat.575)	"	Grano	LID
"	"	"	Espícula	3.5 ± 0.5
"	"	"	Paja	LID
"	A.A.L. (1975-975)	"	Grano	4.6 ± 0.6
"	"	"	Espícula	41 ± 6.5
"	"	"	Paja	78 ± 8.6
"	J.N.C. (cat.494)	"	Grano	1.3 ± 0.2
"	"	"	Espícula	2.7 ± 0.5
"	P.S.S.G. ⑫ (cat.226 y 227)	Trigo ⑪	Paja	0.53 ± 0.06
"	"	"	Grano	LID
"	"	"	Espícula	8.2 ± 1.0

Key: 1) sampling date; 2) estate; 3) vegetable; 4) species; 5) part; 6) concentration of activity; 7) barley; 8) straw; 9) grain; 10) spicule; 11) wheat; 12) and.

Table 6. Content of Plutonium-239 in the Vegetation of Area 5 in 1988.

FECHA DE MUESTREO ①	FINCA ②	V E G E T A L ③		CONC. ACTIVIDAD Bk/kg ⑥
		Especie ④	Parte ⑤	
16-5-88	D.P.G. (1137) (1025)	Cebada ⑦	Grano ⑧	LID
"	"	"	Espícula ⑨	5.4 ± 0.7
"	"	"	Paja ⑩	LID
"	M.A.B. (1225) (962)	Trigo ⑪	Paja	LID
"	M.A.B. (1225)	"	Grano	LID
"	"	"	Espícula	6.9 ± 0.9

Key: 1) sampling date; 2) estate; 3) vegetable; 4) species;
5) part; 6) concentration of activity; 7) barley; 8) grain;
9) spicule; 10) straw; 11) wheat.

Table 7. Content of Plutonium-239 in the Vegetation of Area 2 in 1989.

FECHA DE MUESTREO ①	FINCA ②	V E G E T A L ③		CONC. ACTIVIDAD Bq/kg. ⑥
		Especie ④	Parte ⑤	
13-1-89	M.S.N. (2-2) (610-670)	Tomate ⑦	Fruto ⑧	LID
"	"	"	Fruto lavado ⑨	LID
"	"	"	Planta ⑩	2.24 ± 0.28
"	Cementerio (200-550)	"	Fruto	LID
"	"	"	Fruto lavado	LID
"	"	"	Planta	LID
"	F.L.L. (725-625)	"	Fruto	LID
"	"	"	Fruto lavado	LID

Key: 1) sampling date; 2) estate; 3) vegetable; 4) species; 5) part; 6) concentration of activity; 7) barley; 8) fruit; 9) washed fruit; 10) plant; 11) cemetery.

Table 8. Content of Plutonium-239 in the Vegetation of Area 3 in 1989.

FECHA DE MUESTREO ①	FINCA ②	③ V E G E T A L		CONC. ACTIVIDAD Bq/kg. ⑥
		④ Especie	⑤ Parte	
13-1-89	D.S.M. (cat 538)	Tomate ⑦	Fruto ⑧	0.07 ± 0.002
"	"	"	Fruto lavado ⑨	LID
"	J.F.G. (cat.780)	"	Fruto	0.42 ± 0.05
"	"	"	Fruto lavado	LID
"	"	"	Planta ⑩	LID
"	J.A.L. (cat.448)	"	Fruto	3.6 ± 0.4
"	"	"	Fruto lavado	LID
"	"	"	Planta	LID
"	C.S.G. (cat.781)	"	Planta	LID

Key: 1) sampling date; 2) estate; 3) vegetable; 4) species; 5) part; 6) concentration of activity; 7) tomato; 8) fruit; 9) washed fruit; 10) plant.

Table 9. Content of Plutonium-239 in the Vegetation of Area 5 in 1989.

FECHA DE MUESTREO ①	FINCA ②	V E G E T A L ③		CONC. ACTIVIDAD Bq/kg. ⑥
		Especie ④	Parte ⑤	
13-1-89	J.F.G. 1850-1100	Tomate ⑦	Fruto ⑧	0.06 ± 0.01
"	"	"	Fruto lavado ⑨	LID
"	"	"	Planta ⑩	LID
"	I.N.S. 1000-900	"	Fruto	0.97 ± 0.12
"	"	"	Fruto lavado	LID
"	"	"	Planta	LID
"	B.A.S. 1150-950	"	Fruto	LID
"	"	"	Fruto lavado	LID
"	"	"	Planta	0.16 ± 0.03

Key: 1) sampling date; 2) estate; 3) vegetable; 4) species;
5) part; 6) concentration of activity; 7) tomato; 8) fruit;
9) washed fruit; 10) plant.

Table 10. Content of Plutonium-239 in the Vegetation of the Area 5-3B in 1989.

FECHA DE MUESTREO ①	VEGETAL ②		CONC. ACTIVIDAD Bq/kg. ⑤	
	Especie ③	Parte ④		
13-1-89	5-3B	Tomate ⑥	Fruto ⑦	LID
"	"	"	Fruto lavado ⑧	LID
"	"	"	Planta ⑨	LID

Key: 1) sampling date; 2) vegetable; 3) species; 4) part;
5) concentration of activity; 6) tomato; 7) fruit; 8) washed
fruit; 9) plant.

Table 11. Concentration of Pu-239 + Pu-240 in Samples of Goat Milk.

FECHA DE RECOGIDA ①	VOLUMEN TOTAL ②	CONCENTRACION ③ mBq/litro ④
⑤ 29-05 al 04-06-89	520 ml	≤ 8.68
05-06 al 11-06-89	970 ml	≤ 7.47
12-06 al 18-06-89	1100 ml	20.19 ± 3.83
22-06 al 02-07-89	1100 ml	41.83 ± 7.38
03-07 al 09-07-89	1025 ml	≤ 6.42

Key: 1) date of collection; 2) total volume; 3) concentration; 4) liter; 5) to.